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AGRICULTURAL EXPERIMENT STATION,
DURHAM, N. H.

BULLETIN NO. 21.

FARM YARD MANURES AND ARTIFICIAL FERTILIZERS.

APRIL, 1894.

CONCORD, N. H.:
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1894.

EXPERIMENTS WITH MANURES AND ARTIFICIAL FERTILIZERS.

The experiments recorded in this Bulletin are in part the results obtained at Hanover, N. H., previous to the removal of the Experiment Station to Durham, and in part results at the latter place.

The term *manures* applies to farm-yard manures, and in this case means the mixed manure from cows, young stock, and pigs, with the ordinary amount of absorbents,—such as straw, sawdust, etc. The term *artificial fertilizers* means either the prepared or *commercial* fertilizers, or chemical fertilizers such as are prepared or mixed on the farm.

NATURAL MANURES.

The manure produced by farm animals varies considerably in value, according to the richness of the food, also from the kind of animal producing it, as well as the condition in which the animal is; but by far the most important factor affecting the quality of manure is the manner of *collecting* and *keeping*.

About one half of the value of the manure from an ox or cow is found in the liquid excrement, hence at the outset it becomes necessary to adopt some plan by which this may be saved. The common, and probably the best, plan is to use absorbents, which will readily take up this liquid and save it; but the nitrogen contained in liquid manures is easily fermentable, and when fermenting gives off ammonia, and as this nitrogen represents more than *one third* of the total value of both the solid and liquid excrement, it at once becomes evident that it should be carefully managed, and it was in view of this tendency to loss from fermentation that the following experiments were carried on.

(a) Manure in masses is almost sure to ferment or heat. Some manure, like that from horses and sheep, is more prone to fermentation than other kinds; but all, if left for a long time in large quantities, is sure to develop more or less heat.

(b) All manures contain soluble plant food, and the percolation of water through masses of manure is sure to dissolve out, and, if possible, carry away, this plant food.

In view of these two facts, it becomes a question whether we should allow manure to collect long enough to allow fermentation to take place; and, secondly, whether any method which allows the rains to wash piles of manure should be tolerated by the careful farmer.

The tendency of water to dissolve out the really valuable parts of manure, and carry these constituents in solution, and the further tendency of soil to sort out this material, as the water filters through the soil, and retain it, are facts which also have a bearing on the solution of the problem of how to apply manures.

We are to consider then, first, *when to apply manure;* secondly, *how to apply it;* and, thirdly, *how much to apply.*

SPRING OR FALL APPLICATION OF MANURE.

In Bulletin 6 of this station, page 5, two acres of land are reported on, one having 6 cords of manure on the surface in the fall, the other having 6 cords in the spring.

		Sound corn.	Soft corn.	Fodder.
The yield was	Fall manuring,	3,070 lbs.	754 lbs.	6,066 lbs.
	Spring "	1,690 "	1,084 "	5,271 "

In the fall of 1887 five acres of land were divided into two parts. To one part 35 loads of manure were applied on the surface; the following spring an equal amount was applied to the other half, and the whole planted to ensilage. The yield was not large, as several varieties of corn were planted, three of which did not prove well suited to the climate.

The fall manured half yielded	58,530 lbs.
The spring " "	57,605 "

The difference here is not great, and can hardly be said to give positive evidence for or against either method.

In the fall of 1888 two half acres of land were taken and plowed at the same time. August 20 to one of these was applied, after plowing, 3½ cords of manure, or 10 common cart loads. The other was left until spring, May 20, 1889, and had applied to it 3½ cords of manure. Each half acre received the same treatment and seed, and they were harvested at the same time, with the following results:

Fall manured (spread on surface in Aug.), yield of ensilage per acre, 16.48 tons.
Spring " " " May), " " " 11.72 "

Cuts Nos. 7 and 12 show ten average stalks bunched from each lot. No. 7 gives the fall manured, and No. 12 the spring manured.

Another pair of half-acre plots, where twice as many cords of manure were used, namely, 7 cords or 20 cart loads, gave the following results:

Fall manured (plowed in), cut No. 6, yielded . 23.17 tons.
Spring " " 2, " . 24.50 "

Here we have an experiment where the spring-applied manure gave best results. The plowing in of fall-applied manured on sod land is not to be recommended, and the results above recorded are no more than might have been expected, since it gave no chance for frost and rain to pulverize and distribute the manure.

HOW SHALL WE APPLY MANURE?

There was a time when it was regarded as settled that the losses from manure were through the air, that is, that the escape of ammonia was the great thing to be guarded against, and, indeed, under the then prevailing custom of allowing manures to heat,—either in piles in the yard, or, worse still, in the large heaps that were so often and are now occasionally seen where the manure has been drawn from the barn to the field, to be stored unprotected until the season for planting—this was true. Here the most favorable conditions possible for fermentation, and the attendant formation of ammonia compounds from the liquid part of the manure, are to be found, and here it is that the manure is really wasted in the air; but, aside from this inexcusable

method, the management of manure can hardly be planned so that the loss will be through the air, but rather will it result from the downward passage of soil waters. The drainage water from our fields carries fertility away, not rapidly, it is true, but appreciably, and it is the brook that wanders through our fields, and not the winds that blow over them, that rob our manured and unmanured fields of their fertility. With this view of the case, we should so place our farm-yard manure that it shall have just as much soil as possible to filter through.

Rain falling on a field, whether the field is level or considerably sloping, tends first of all to enter the soil, just as water falling on a sponge is absorbed, and the filtering away of this water causes it to flow along through the soil, not over its surface. There are exceptions; a field may be so steep that a heavy rain-fall will rush down its surface and mechanically carry away soil and manure, or the land may be so full of water that rain-water does not freely filter through it, but even then the surface water is bound to crowd out that already in the soil; so that the exceptions, while existing, are not to be considered as of more importance than the general run of cases.

Surface manuring is the logical result of a study of the facts relating to fertilizing in general, but by surface manuring I do not mean that the manure should be allowed to remain *on* the very top of the soil, but rather that it should be mixed with the top two or three inches of soil, and the more intimately it is mixed the better. And right here is where *fall surface* manuring derives its chief advantage.

I have repeatedly seen as high as forty loads of coarse green manure spread on the surface of an acre of land in the fall. To have harrowed this quantity in so that little or no manure should have been left in sight, would have been an impossibility with any form of harrow that we now have; and yet after the fall rains, the winter snows and frosts, and the spring rains had worked on that manure, an ordinary harrowing would completely incorporate it into the soil: in fact, the elements had themselves mixed the plant food with the soil, and the manure had become pulverized and as fine as compost, and with none or very little of the loss that results from rotting

or composting as ordinarily practised. Returning now to our experiments, I will quote from Bulletin 6, page 5, New Hampshire Experiment Station,—

	Sound corn.	Soft corn.	Fodder.
One acre, manure plowed in, fall applied,	2,690	935	5,555
" " on surface "	3,070	754	6,066

From our 1890 experiments,—

	Manure per acre.	Yield per acre.
Surface manured, cut 5 .	14 cords manure .	24.70 tons ensilage.
Plowed in, " 6 .	14 " .	23.17 "
Surface manured, " 7 .	7 " .	16.48 "
Plowed in, " 8, .	7 " .	16.13 "

These experiments do not show as marked differences as are often obtained, for the reason that in most cases an excessive amount of manure was used, far more than the crop could utilize.

HOW MUCH MANURE CAN WE USE?

No precise answer can possibly be given to this question, for the limit is set by the kind of crop and the nearness to market.

There is an amount of manure or fertilizer that can be used to greatest profit; then we may increase this amount and get increased crops, but the value of the increase is not in proportion to the cost of the additional manure; or we may use less, but not to as good advantage. In general the greater the market value of the crop, the greater the amount of manure that can be profitably used, and hence we cannot lay down any general rule that will apply equally to the general and special farmer.

There is another difficulty in the way of even experimentally determining how much fertilizer or manure can profitably be used, and that is the uncertainty as to the value of the manure left in the soil after the first crop is taken off. In the experiments above given, two widely varying amounts of manure were used. One, 7 cords or 20 common loads per acre, is about what our best farmers use in mixed farming; the other, 14 cords or 40 loads, represents very high manuring, so far as the common lines of farming are concerned. Take the half-acre plots represented by cuts 6 and 8: the former had $42 worth of

manure, while the latter had only $21 (this is at the comparatively low price of $3 per cord); the investment of $21 gave a gain over no manure (plot 9) of 11.44 tons of ensilage, or the cost of manure per ton of ensilage for the first 20 loads was $1.83. Now when we apply an additional 20 loads to the same land, we get as the increase due to the last amount of manure, the difference between the yield of plot 6 (23.17) and plot 8 (16.13), which is almost exactly 7 tons, or a ton for $3 worth of manure. Now, so far as this evidence goes, it is plain that 20 loads was profitable, while the additional 20 was not.

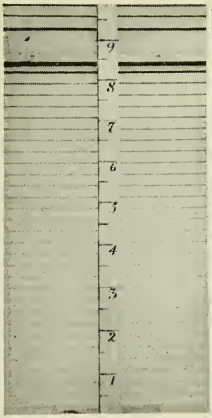
But the question comes up, How about the residue left in the soil in these two plots? This question cannot be answered, for many reasons. First, we know very little of the availability of the plant food in the manure; second, we know next to nothing of the amount lost in the drainage water; third, we have no knowledge as to the condition of the plant food that is thus left in the soil. Without doubt some portion of it is rendered insoluble by the action of the soil, thus making it of no more value than the unavailable plant food which most soils contain in considerable quantities.

In general, I do not believe that more than from 15 to 20 loads (5 to 7 cords) of manure can be advantageously used on our field crops, like corn, oats, barley, and grass; and I do not believe that 40 loads of manure (14 cords) can be applied to two acres with more profit than to one acre.

SUBSTITUTES FOR FARM-YARD MANURE.

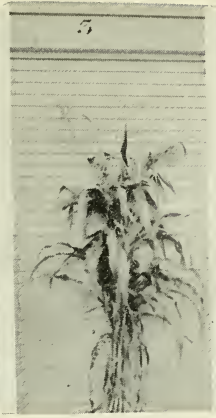
The subject of chemical fertilizers has been carefully studied by this station, and the results can be found in Bulletins 5, 6, 10, and 12; but as new results are year by year being added, a short statement will not be out of place in this bulletin.

The results of all our work show, without exception, that New Hampshire soils are more in need of potash than any other element of plant food, and consequently, that we may so compound our fertilizers that better results shall follow their use than is possible with the average fertilizer found in our markets, and this the farmer is enabled to do by buying his

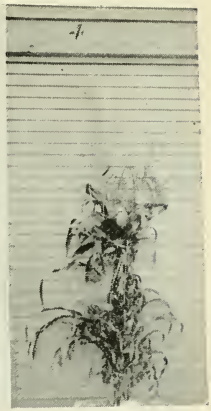


Chemicals.
D. B. B., 404 lbs.,
M. P., 122 1-2 lbs.,
S. A., 86 lbs.,
1,986 tons ensilage.
Cost of fertilizer, $12.25 per half acre.

Spring manured.
Plowed in 14 cords per acre,
24.5 tons ensilage.
Cost of fertilizer, $24.50 per half acre.



Manured on snow.
Feb. 15, 1889, 14 cords per acre,
16.11 tons ensilage.
Cost of fertilizer, $24.50 per half acre.



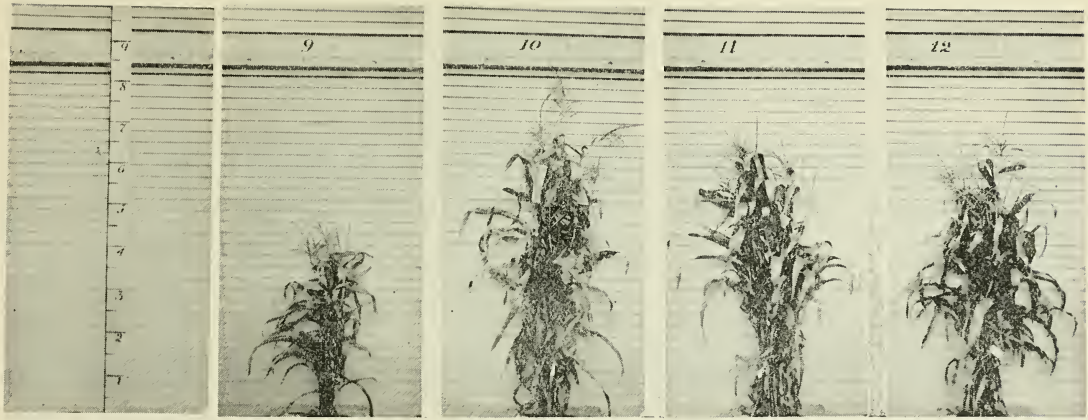
Manured on snow.
Feb. 11, 1889, 7 cords per acre,
10.18 tons ensilage per acre.
Cost of fertilizer, $12.25 per half acre.

Fall manured.
Surface,
14 cords per acre,
24.70 tons ensilage.
Cost of fertilizer, $24.50.

Fall manured.
Plowed in,
14 cords per acre,
23.17 tons ensilage.
Cost of fertilizer, $24.50.

Fall suiface-manured.
7 cords per acre,
16.48 tons ensilage.
Cost of fertilizer, $12.25.

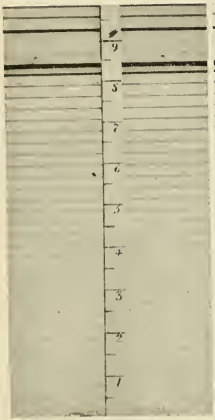
Fall manured.
Plowed in,
7 cords per acre,
16.13 tons ensilage.
Cost of fertilizer, $12.25.



No manure or chemicals.
4.69 tons ensilage.

Leached ashes.
244 bushels,
16.88 tons ensilage.
Cost of fertilizer, $12.25.

Whole ashes.
98 bushels,
13.6 tons ensilage.
Cost of fertilizer, $12.25.

Spring surface manured.
7 cords per acre,
11.72 tons ensilage.
Cost of fertilizer, $12.25.

Bowker's Hill and Drill.
680 lbs. per acre,
16.93 tons ensilage.
Cost of fertilizer, $12.25.

Chemicals.
D. B. B., 404 lbs.,
M. P., 122½ lbs.,
S. A., 86 lbs.,
16.01 tons ensilage.
Cost of fertilizer, $12.25

crude fertilizing chemicals and mixing as his soil and crops require.

Any farmer in this state may, if he will, purchase these chemicals of the wholesale dealers or fertilizer manufacturers, and he is then in position to adapt his fertilizers to the crops and soil he is dealing with.

A compilation of all our results thus far obtained gives us the following table, in which one may see at a glance the relative profit resulting from the use of chemicals and the best prepared fertilizers:

On Hanover farm $1 invested in prepared fertilizers gave increased crop, valued at $1.80.

On Hanover farm $1 invested in chemical fertilizers gave increased crop, valued at **$2.80.**

On ten New Hampshire farms, coöperative test, $1 invested in prepared fertilizers, on corn, gave increased crop, valued at $0.74.

On ten New Hampshire farms, coöperative test, $1 invested in chemical fertilizers, on corn, gave increased crop, valued at **$1.71.**

On ten New Hampshire farms, coöperative test, $1 invested in prepared fertilizers, on sweet corn, gave increased crop, valued at $2.91.

On ten New Hampshire farms, coöperative test, $1 invested in chemical fertilizers, on sweet corn, gave increased crop, valued at **$3.03.**

On ten New Hampshire farms, coöperative test, $1 invested in prepared fertilizers, on potatoes, gave increased crop, valued at $2.07.

On ten New Hampshire farms, coöperative test, $1 invested in chemical fertilizers, on potatoes, gave increased crop, valued at **$4.20.**

On ten New Hampshire farms, coöperative test, $1 invested in prepared fertilizers, on potatoes, gave increased crop, valued at $4.20.

On ten New Hampshire farms, coöperative test, $1 invested in chemical fertilizers, on potatoes, gave increased crop, valued at **$6.05.**

These results represent more than 500 individual tests, and it cannot be that the results thus obtained are accidental: they rest on some law, and from a study of the conditions of the experiments we are brought to the conclusion that the prepared goods are deficient in potash. The following table shows the per cents. of nitrogen, phosphoric acid, and potash in the combinations of chemicals that in actual practice have proved best:

	Nitrogen per cent.	Phos. acid per cent.	Potash per cent.
Best results on plots at Hanover came from mixtures containing	2.5	5.75	25.0

	Nitrogen per cent.	Phos. acid per cent.	Potash per cent.
Best results on seven New Hampshire farms (husked corn)	4.7	9.0	10.7
Best results on seven New Hampshire farms (fodder)	2.3	9.5	11.9
Best results on potatoes	2.3	11.6	7.1
Best results on sweet corn	2.1	10.8	11.0
Best results on ensilage	.0	4.0	24.0
Best results on potatoes (2d series)	2.8	9.7	12.4
Average composition of mixtures of chemicals that have produced best results	2.4	8.6	14.6
Average composition of fertilizers sold in the state	3.0	12.0	3.0

RELATIVE EFFICIENCY OF CHEMICALS AND FARM-YARD MANURES.

Can chemical manures compete with farm-yard manures? Will they hold out?—These are questions that are asked hundreds of times every year by careful farmers.

The experiment begun at Hanover in 1885, and reported on at times as the work progressed, is now completed, the full rotation having been accomplished the year before the station was moved from that town.

Two acres of land, from a field of six acres, were selected for this experiment. The land had produced hay for three years previous to 1885; oats and sugar-beets had preceded the hay.

The third acre had 13 loads of manure plowed in and 9 loads harrowed in, or in cords this would be 5.6 cords plowed in and 3.8 cords on surface, or 9.4 cords in all, which would sell, as it lay under the stables, for $33. This manure was from fattening steers, well fed with hay, straw, cotton seed, and corn meal. The fourth acre had yearly applications of chemical fertilizers, mixed as follows:

Dissolved bone-black	346 lbs.
Muriate of potash	150 "
Sulphate of ammonia	55 "

The average cost of this mixture has been $11, and as there have been three applications since 1885, it follows that each acre has received $33 worth of fertilizer; the third having

$33 worth of manure, and the fourth $33 worth of chemicals. The first year the crop was corn, the second year corn, the third oats, and the fourth, fifth, and sixth, grass.

The following table shows the yield of each acre for each year, and also the value of the crop, assuming 80 pounds of corn as harvested to be worth 60 cents, 34 pounds of soft corn 10 cents, and fodder 30 cents per hundred, oats 50 cents per bushel, straw 30 cents per hundred, and hay $10 per ton:

		Third acre,—manure.		Fourth acre,—chemicals.		Total yield with manure.	Total yield with chemicals.
		1885.	1886.	1885.	1886.		
Corn	Sound*	112 bu.	83¾ bu.	97 bu.	82½ bu.	195½ bu.	179¾ bu.
	Soft	16½ bu.	27 bu.	15 bu.	24 bu.	43½ bu.	39 bu.
	Fodder	4,835 lbs.	4,435 lbs.	5,352 lbs.	4,927 lbs.	9,270 lbs.	10,279 lbs.
	Value	$49.75	$41.12	$46.65	$42.00	$90.87	$88.65
		1887.					
Oats	Grain†	43 bu.		47⅓ bu.			
	Straw	4,535 lbs.		5,267 lbs.			
	Value	$35.10		$39.55		$35.10	$39.55
		1888.					
Hay	Yield	5,880 lbs.		6,202 lbs.			
	Value	$29.40		$31.01		$29.40	$31.01
		1889.					
Hay	Yield	4,200 lbs.		4,800 lbs.			
	Value	$21.00		$24.00		$21.00	$24.00
		1890.					
Hay	Yield	3,700 lbs.		2,800 lbs.			
	Value	$18.50		$19.00.		$18.53	$19.00
Total crop for six years						$194.87	$202.21
Excess of value produced by chemicals						$7.34	

* Sound corn, 40 lbs. per bushel; soft corn, 34 lbs. per bushel.
† Oats, 32 lbs. per bushel.

Plots on which no manure or chemicals were used for the same six years, gave us crops valued at $128.77, so that we have a gain of crops on the manured acre valued at $66.10, and this is the result of investing $33. On the acre fertilized with chemicals the excess is valued at $73.44.

This experiment I regard as a safe one for farmers to study, as it was on a large scale, and under the most favorable circumstances so far as the uniformity of soil and treatment were concerned.

In the series of experiments represented by the cuts in this bulletin made in 1889–'90, we have a comparison of the efficiency of chemicals, prepared fertilizers, and manure, on land which had been fertilized with ashes either in 1879 or 1880 and had since been in grass.

PREPARED FERTILIZERS, CHEMICALS, AND ASHES COMPARED.

	Cost.	Yield.
Plot 1 had the following chemicals { dissolved bone-black, 404 lbs., muriate of potash, 122½ lbs., sulphate of ammonia, 86 lbs., }	$12.25	19.85 tons.
* Plot 14, the same as plot 1	12.25	16.01 "
Plot 13 had 680 lbs. of Bowker's Hill and Drill Phosphate	12.25	16.93 "
Plot 10 had 244 bushels of leached ashes . . .	12.25	16.88 "
Plot 11 had 98 bushels of whole ashes	12.25	13.60 "

The amount and cost of the fertilizer above is per *half* acre, but the yield is computed per acre, as we are more accustomed to think of the amount we produce per acre.

MANURE AND ARTIFICIAL FERTILIZERS.

Plots 10–14 form a series which may be studied by themselves, and as the yield of 10, 11, 13, and 14 do not vary greatly, except 11, we will average them and compare them with No. 12, which was spring manured.

Fertilized with.	Cost per acre.	Tons.
Plot 10, leached ashes, " 11, whole ashes, " 13, Bowker's H. and D. Phosphate, " 14, chemicals,	$12.25	average yield, 15.85
" 12, 3½ cords of manure,	12.25	yield, 11.72
Gain in favor of artifical fertilizer,		4.13

* Plots 10 to 14 had some six or eight years previous to this experiment been fertilized with ashes.

This is, however, the gain over manure spring applied. If we take plot 7, where $12.25 worth of manure was fall applied, we get a yield of 16.48 tons, a gain of 0.63 tons in favor of manure.

Or, take plots 1, 4, 7, and 8, another series that may be compared, because the fertilizer used on each represents the same cost.

	Cost of fertilizer per half acre.	Yield per acre.
Plot 4, manured Feb. 11, 3½ cords per half acre,	$12.25	10.18 tons.
" 7, " fall, " " "	12.25	16.48 "
" 8, " " " " "	12.25	16.13 "
Average		14.26 "
Plot 1, chemicals, { bone-black, 404 lbs. per half acre, muriate of potash, 122½ lbs. " sulphate of ammonia, 86 lbs. " }	12.25	19.85 "
Gain resulting from chemicals instead of manure . .		5.59 "

In a series of experiments carried on at Durham, under the supervision of Mr. D. E. Stone, the following results were obtained:

	Cost per half acre.	Yield per acre.
Plot 2, (one half acre), 5 cords manure,	$17.50	15 08 tons.
" 4, " " 10 "	35.00	16.32 "
" 3, " " chemicals { dis. b. black, 162 lbs., mur. of pot., 50 " sulp. of am., 38 " }	5.00	13.56 "
" 6, " " Stockbridge manure, 250 lbs.,	5.00	8.13 "
" 7, " " Bowker's H. and D., 250 lbs.,	4.50	8.48 "
" 8, no fertilizer of any kind		5.46 "

In this series we see that the comparatively small amount of fertilizer used on plot 3, costing only $5, gave a very creditable yield, even alongside of $17.50 worth of manure; and that $10 per acre gave an increased crop of 8.10 tons. or a ton at a cost of $1.23, but this is on the assumption that all of the chemicals were used up last year, which will not prove to be the case.

CHEMICAL FERTILIZERS—HOW TO MIX AND USE.

WHAT THE CHEMICALS ARE AND WHAT THEY CONTAIN AND WEIGH.

				Weight per ½ bu.
Dissolved bone-black	contains 16	per cent.	soluble phosphoric acid,	30 lbs.
Muriate of potash	" 50	"	actual potash,	34 "
Sulphate of ammonia	" 20	"	nitrogen,	31 "
Nitrate of soda	" 15	"	nitrogen,	44 "

STANDARD COMBINATIONS.

No. I.
For Corn.

	lbs.
Dissolved bone-black	325
Muriate of potash	100
Sulphate of ammonia	75
	500

No. 4.
For Ensilage.

	lbs.
Dissolved bone-black	250
Muriate of potash	200
Sulphate of ammonia	50
	500

V.
For Oats.
(Or use No. 1.)

Dissolved bone-black	325
Muriate of potash	125
Sulphate of ammonia	50
	500

No. VII.
For Hay.

Dissolved bone-black	225
Muriate of potash	250
Nitrate of soda	25
	500

IX.
For Potatoes.
(Following a manured crop.)

Dissolved bone-black	340
Muriate of potash	160
	500

X.
For Potatoes.
(On poor ground.)

Dissolved bone-black	300
Muriate of potash	150
Sulphate of ammonia	50
	500

These chemicals are all dry, harmless substances, as easily mixed as corn meal, shorts, and middlings. The combinations are vastly superior to the prepared fertilizers on the market,

chiefly because they are entirely soluble and contain a *high per cent. of potash.*

The amounts are for one acre where no manure is used, and in *every case* on *planted* crops use either 300 or 350 pounds of the mixture broadcast, putting only from 150 to 200 in the hill or drill, and *do not let it come in contact with the seed.*

This cost, on an average, about as follows:

Dissolved bone-black	$25–$30 per ton.
Muriate of potash	42– 45 "
Sulphate of ammonia	78– 80 "

and may be bought of any fertilizer manufacturer.

CONCLUSIONS.

Manure applied in the fall to the surface, either of plowed or grass land, will, by the action of frost and rain, become so thoroughly pulverized and distributed through the soil that it acts more quickly, and is in better condition for plants to assimilate, than the same manure would be if applied in the spring.

The loss from evaporation and drainage (unless the surface is very steep) will probably be much less than the loss resulting from fermentation if the manure is allowed to accumulate in cellars or the washing if left in open yards.

On most soils, and for most crops, surface application is better than plowing in, and especially if manure is applied in the fall, but in any case, except for manure that is so coarse that it cannot be mixed with the soil by cultivation, it is a safe rule to keep the manure as near the surface as possible, and to have it as thoroughly mixed with the seed-bed as can be done. This carries with it the necessity of using only such bedding and absorbents as are of themselves fine or easily pulverized.

For our common field crops—corn, oats, rye, barley, potatoes, etc.—it is not profitable to use more than from 15 to 20 cart loads (5–7 cords) of manure per acre.

On an average, on New Hampshire soils and with general crops, $1.00 invested in the best prepared fertilizers has given an increase of crop valued at $2 34, while $1.00 invested in the chemicals—dissolved bone-black, muriate of potash, and

sulphate of ammonia—has given an increase valued at $3.56—a difference of $1.22 in favor of, and due entirely to, the substitution of chemicals for prepared fertilizers, at equal cost.

This difference is due chiefly to the wrong properties of plant food in the prepared fertilizers, and more to the deficiency of potash than any other cause.

Prepared fertilizer gives	phosphoric acid	12.0	per cent.
	potash	**3.0**	"
	nitrogen	3.0	"
While the chemicals that give best result contain	phosphoric acid	8.6	"
	potash	**14.6**	"
	nitrogen	2.4	"

Chemicals properly mixed and used can and do give as good returns as farm-yard manure, and oftentimes better, and this in a six years rotation.

Leached ashes gave better results per dollar invested than whole ashes.

G. H. WHITCHER,
Director.

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